

hours 10 to more than 12 inches of rain fell in the extreme northwest part of the westerly subdrainage area above Chillicothe. In the remainder of the basin 3 to 6 inches fell. Most of the rain, and probably enough to cause a disastrous flood, fell in the 24 hours ending at 7 a. m. of the 10th. A very rapid rise began in the tributary streams on the 10th, and in the main stream as far south as Chillicothe on the 11th. Very high stages were general, except near the mouth of the river. The bottoms are broad throughout the system; all of them above Chillicothe were covered, and below the widely inundated area extended almost to the Missouri River. The water receded slowly, as is usual in this system, thus augmenting the seriousness of the situation.

The stage of the Missouri River was moderate throughout the flood in the Grand, and the discharge near the mouth of the Grand was sufficiently rapid to keep the maximum stage down to a level that was not more than 5 feet above bankful.

There are three rainfall charts inclosed.¹ They show the precipitation that caused the floods of July, 1909, June, 1917, and July, 1922. There is also forwarded herewith a tabular statement of the annual maximum stages of the Grand River at Chillicothe.

WARNINGS ISSUED.

At 10 a. m. of July 10, the following telegraphic warnings were issued: To Pattonsburg, Gallatin, and Trenton, Mo.—Heavy rains upstream. River will rise rapidly and pass bankful stage.

To Chillicothe.—Heavy rains upstream. Grand will rise rapidly, passing flood stage in 36 hours.

To Brunswick.—Heavy rains over Grand, and in northwest Missouri. River will pass flood stage by Wednesday (12th).

At 3 p. m. of the same day, after receipt of additional rainfall reports, further warnings were telegraphed as follows:

To Pattonsburg, Gallatin, Trenton, and Chillicothe, Mo.—Very heavy rains falling in northern counties from Putnam to Nodaway. Amounts sufficient to give high flood. Disseminate widely.

To Brunswick.—Very heavy rains falling in northern counties from Putnam to Nodaway. Amounts sufficient to cause high flood above Brunswick. Rise at Brunswick depends upon action of Missouri, which can not be estimated until Tuesday (11th).

On the 11th a stage of 14 feet was forecast for Brunswick.

On the 12th a crest stage of 30 feet was forecast for Chillicothe, and the river observer at that place was asked to disseminate the information as widely as possible.

When the first warnings were telegraphed the stages were low. The Chillicothe stage was 5.3 feet, which is 12.7 feet below bankful stage. All of the warnings were given as thorough a dissemination as possible. The Chillicothe Chamber of Commerce and the telephone companies in the basin spread the information among the farmers by telephone. The time that was available for the driving of live stock out of the bottoms and moving the shocked wheat was ample. Most of those having property of this kind in exposed places began to move it upon receipt of the first warning. There were some, however, who were doubtful that the river would rise high enough to cause any damage, and lost all of their bottom wheat and most of their live stock running in the bottoms.

Thousands of acres of growing corn were a total loss. Some corn on the edge of the flooded area survived the inundation, but in most of the bottom land the crop was covered three to six days and was killed. On account of the lateness of the season, replanting had to be confined to a few forage crops.

There was one human life lost during the flood, that of a boy of 17, who was drowned on July 12 while driving cattle from flooded lowlands near Brimson, Grundy County.

The following is a tabulation of the statistical reports concerning flood losses and the value of the warnings in Daviess, Grundy, Livingston, Carroll, and Chariton Counties, Mo.:

Damage to highways, bridges, farm buildings, etc.	2	\$80,000
Loss of crops, which may or may not have been housed....		530,000
Loss of prospective crops, 57,300 acres.....	1,432	500
Loss of livestock or other movable property.....	2	11,500
Loss due to suspension of business, including wages of employees.....		87,000
Money value of property saved by warnings.....	1,790	000

Highest stages at Chillicothe for 1909 and for 1915 to 1922, inclusive. There are no records for the period 1910 to 1914, inclusive.

	Stage.		Stage.
1909.....	33.6	1919.....	29.8
1915.....	30.1	1920.....	26.9
1916.....	27.0	1921.....	19.2
1917.....	31.5	1922.....	30.5
1918.....	21.0		

¹ Not reproduced.

² For Livingston County only.

There is inclosed herewith a copy of resolutions adopted by the Chamber of Commerce of Chillicothe, Mo., expressing its appreciation of the work of the Weather Bureau in connection with this flood.

THE HIGHWAY CITY—THE CHAMBER OF COMMERCE—COURTESY TOWN—CHILICOTHE, MO.

BOARD OF DIRECTORS' MEETING, JULY 13, 1922—A RESOLUTION OF APPRECIATION TO ST. LOUIS WEATHER BUREAU.

Whereas the warning sent out by telegraph through the local station representative by the Government Weather Bureau at St. Louis, giving from 30 to 36 hours' notice in advance of a 30-foot flood stage in the Grand River Valley in Livingston County, caused by a heavy down-pour about July 10th, in the northwest part of the State; and

Whereas said telegram contained the further warning to all farmers and others in the lowlands to make every effort to save their harvested crops, their live stock, and to remove same to the higher lands; and

Whereas many of our farmers heeded the warning and did save some of their crops and nearly all their live stock, while others, we regret to say, did not heed the warnings; and

Whereas the Chillicothe Chamber of Commerce, by the information contained in said Government Weather Bureau warning, was put in a position to cooperate in distributing this information to our rural district lowland farmers: Therefore be it

Resolved, At this a regular board of directors' meeting, held on the above date (motion made by E. O. Welch, seconded by W. C. Arnold, and passed unanimously), "That a proper resolution be prepared by the secretary commending the Government Weather Bureau office at St. Louis for furnishing advanced report and warning to the people of Livingston County from 30 to 36 hours, relative to the recent flood, so that they could get their stock and crops out of the lowlands prior to the arrival of the flood. And also to request that if the Government office at St. Louis will furnish the chamber of commerce with a copy of all future information of this nature which comes to their local representative, the chamber will be able to facilitate in getting this information out over the county much quicker."

BOARD OF DIRECTORS,
By HARRY W. GRAHAM, *Secretary*.

There was also a general overflow of the smaller streams of northeastern Nebraska on July 30, and according to press reports towns and farm lands were damaged to the extent of \$1,000,000.

The rise in the Arkansas River and tributaries from the Wichita district southward was not serious except in the Little Arkansas River. The total damage reported was about \$55,000, of which about \$40,000 was in crops. Warnings were issued well in advance of the rises.

ANNUAL RISE OF THE COLUMBIA RIVER, 1922.

By R. C. MIZE, Meteorologist, Portland, Oreg.

Reports at the end of March showed practically the entire season's snowfall on the ground in the mountain areas. The depth was about average, the snow somewhat less compact than usual, streams unusually low, and the soil fairly well filled with moisture. Forecast was made at that time that with normal temperature conditions there should be a crest of about 20 feet at Portland, and that this stage might be exceeded should there be 10 days or more of continued hot weather late in May or early in June.

At the end of May an usually hot spell prevailed, the last four days of the month showing an excess of 56° above normal. At this time the river was 5 feet lower than on the same date of the preceding year. Moderately hot weather continued until June 8, by which time the stage was but 2 feet lower than that of one year before. The crest was reached at Portland on the average date, June 11. The flood stage was reached on May 21, one day later than the average, and continued six days less than the average. The crest was 0.1 foot higher than

the one and three day forecasts and 0.2 foot higher than the two-day forecast.

All the larger dikes held, and comparatively little tilled ground was flooded. The greatest item of loss reported was due to suspension of business, and of this about one-half was suffered by the salmon-fishing industry.

Flood stages were not reached on the Snake River, nor at Umatilla, Celilo, The Dalles, or Cascade Locks on the Columbia River.

There were three crests in the Snake River at Lewiston: 15.0, May 19; 15.6 May 26; and 16.1, June 7. The first and third were evidently caused by the Clearwater River. The highest stage at Lewiston was reached when the upper Columbia River at Wenatchee had approached within 1 foot of its crest.

Summaries of flood data and loss and damage are appended.

Flood data for 1922 and comparative data.

1922					Comparative data.				
Station.	River.	Flood stage.	Duration (days).	Crest height.	Date of crest.	Highest record.	Average date of crest.	Average height of crest.	Mean June, 1922.
Welser.....	Snake.....	14	0	11.6	May 27.....	26.5	May 31	11.5	8.3
Kamiah.....	Clearwater.....	14	4	14.4	June 5.....	15.4	May 24	13.5	10.2
Lewiston.....	Snake.....	22	0	16.1	June 7.....	26.6	May 30	16.1	12.6
Bonners Ferry.....	Kootenai.....	26	3	25.7do.....	32.7	June 9	24.8	22.0
Newport.....	Pend Oreille.....	18	23	18.0	June 15-17.....	24.9	June 12	16.2	17.2
Marcus.....	Columbia.....	24	44	30.5	June 18-19.....	33.8	June 22	30.5	28.8
Wenatchee.....	do.....	40	10	40.4	June 15-18.....	58.0	June 14	38.5	38.1
Umatilla.....	do.....	25	0	32.6	June 8.....	34.5	June 8	21.6	20.2
Celilo.....	do.....	30	0	19.3	June 9.....	23.4	June 9	17.4	16.6
The Dalles.....	do.....	40	0	38.2do.....	59.6	June 11	37.7	33.7
Cascade Locks.....	do.....	46	0	30.2	June 9-10.....	49.6	June 10	29.0	26.2
Vancouver.....	do.....	15	45	23.4	June 11.....	24.8	June 13	21.0	21.0
Portland.....	Willamette.....	15	43	22.4	June 11-12.....	23.0	June 11	20.4	20.1

Highest summer stages, Willamette River, Portland, Oreg.

Year.	Feet.	Year.	Feet.	Year.	Feet.	Year.	Feet.	Year.	Feet.
1876.....	28.2	1887.....	25.7	1896.....	23.8	1905.....	13.6	1914.....	16.8
1879.....	20.5	1888.....	18.2	1897.....	23.7	1906.....	13.4	1915.....	12.6
1880.....	27.3	1889.....	10.0	1898.....	20.7	1907.....	19.2	1916.....	23.9
1881.....	19.7	1890.....	20.1	1899.....	24.2	1908.....	21.2	1917.....	23.8
1882.....	25.1	1891.....	14.1	1900.....	17.8	1909.....	21.6	1918.....	19.2
1883.....	17.8	1892.....	19.3	1901.....	20.8	1910.....	19.1	1919.....	18.6
1884.....	20.2	1893.....	22.0	1902.....	21.8	1911.....	19.2	1920.....	14.8
1885.....	14.5	1894.....	33.0	1903.....	21.0	1912.....	19.7	1921.....	24.3
1886.....	20.0	1895.....	16.3	1904.....	20.8	1913.....	21.0	1922.....	22.4

Statistics of money loss by flood.

Kind of loss or damage.	In Portland.	Outside.	Total.
Buildings, etc.....	\$1,795	\$17,335	\$19,130
Crops.....		7,300	7,300
Prospective crops (acres, 4,186).....		39,845	39,845
Movable property.....		4,605	4,605
Suspension of business.....	5,500	43,038	54,538
Total.....	7,295	118,133	125,428
Saved by warnings.....	112,500	25,515	138,015

Flood stages during July, 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.					
<i>Connecticut:</i>	<i>Feet.</i>			<i>Feet.</i>	
White River Junction, Vt.....	13	(1)	2	14.0	2
<i>Roanoke:</i>					
Weldon, N. C.....	30	21	21	31.0	21
<i>Neuse:</i>					
Smithfield, N. C.....	14	21	21	14.5	21
<i>Cape Fear:</i>					
Elizabethtown, N. C.....	22	21	21	22.5	21
<i>Black:</i>					
Kingstree, S. C.....	12	24	25	12.4	24
<i>Santee:</i>					
Rimini, S. C.....	12	8	9	12.5	9
Do.....	12	21	30	13.3	23-24
Ferguson, S. C.....	12	9	9	12.0	9
Do.....	12	19	(2)	13.0	25-26
MISSISSIPPI DRAINAGE.					
<i>Arkansas:</i>					
Ralston, Okla.....	12	13	16	13.4	15
<i>Little Arkansas:</i>					
Sedgwick, Kans.....	18	11	11	20.8	11
<i>Neosho:</i>					
Oswego, Kans.....	17	13	15	19.7	14
Yonkers, Okla.....	14	13	14	17.7	14
<i>North Canadian:</i>					
Woodward, Okla.....	3	3	3	3.3	3
<i>Grand:</i>					
Chillicothe, Mo.....	18	12	24	30.5	14
Brunswick, Mo.....	10	12	24	14.9	18
COLORADO DRAINAGE.					
<i>Colorado:</i>					
Parker, Ariz.....	7	(1)	18	9.3	1
PACIFIC DRAINAGE.					
<i>Columbia:</i>					
Marcus, Wash.....	21	(1)	13	27.0	1
Vancouver, Wash.....	15	(1)	4	16.7	1
<i>Willamette:</i>					
Portland, Oreg.....	15	(1)	2	15.9	1

¹ Continued from June.

² Continued into August.

MEAN LAKE LEVELS DURING JULY, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., August 4, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes. ¹			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during July, 1922:				
Above mean sea level at New York.....	Feet. 602.49	Feet. 580.67	Feet. 572.76	Feet. 246.92
Above or below—				
Mean stage of June, 1922.....	+0.29	+0.13	-0.15	+0.17
Mean stage of July, 1921.....	-0.10	+0.23	-0.14	+0.55
Average stage for July, last 10 years.....	-0.14	-0.35	-0.20	+0.04
Highest recorded July stage.....	-1.33	-2.91	-1.65	-1.80
Lowest recorded July stage.....	+1.01	+0.77	+1.30	+2.33
Average relation of the July level to:				
June level.....		+0.10	0.00	-0.10
August level.....		+0.10	+0.20	+0.30

¹ Lake St. Clair's level: In July, 575.42 feet.